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(71) Applicant: ADC TELECOMMUNICATIONS, INC. [US/US]; 12501 Whitewater Drive, Minnetonka, MN 55343 (US).

(72) Inventor: SOLUM, Jeff; 4900 West 78th Street, Bloomington, MN 55435 (US).

(74) Agent: FOGG, David, N.; Fogg, Slifer & Polglaze, P.A., P.O. Box 581009, Minneapolis, MN 55458-1009 (US).

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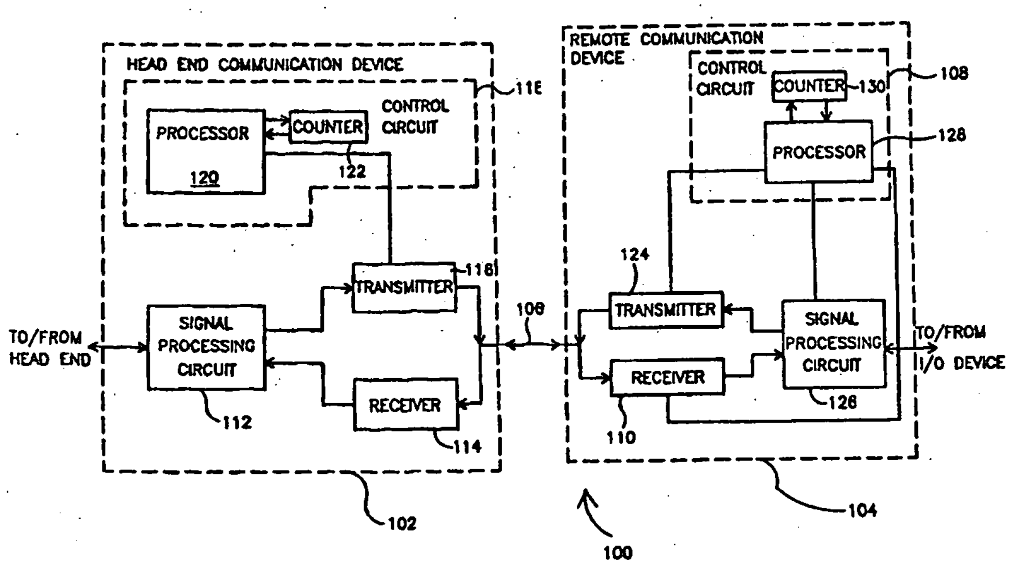

(57) Abstract

A method for controlling power consumption in a communication device is provided. The method includes powering down a receiver of the communication device for a selected period of time and, when the selected period of time expires, powering up the receiver to check for incoming data.

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Reduced Power Consumption in a Communication Device

Technical Field of the Invention

The present invention relates generally to the field of telecommunications and, in particular, to reduced power consumption in a communication device.

Background

Telecommunications networks provide a medium for communicating signals between communication devices. For example, the public switched telephone network (PSTN) typically carries signals representing voice communications between telephones coupled to the telephone network. The telephone network can also carry signals that represent other types of communications, such as data between computer modems or other communication devices.

Another typical telecommunications network is the cable network. The cable network conventionally carries signals representing video programming from a head end to subscriber's equipment, e.g., a television or a set top box.

The cable industry has recently experimented with bi-directional communication over existing cable networks. Bi-directional communications allow cable networks to provide, for example, video-on-demand, Internet access and telephony services over existing cable networks. These services are implemented by connecting subscriber's equipment to the cable network via a cable modem or other appropriate communications device.

With the conventional telephone system, the communication devices, e.g., telephones, are typically powered by the telephone network. Since the telephone network uses batteries to back-up line power, a conventional telephone functions properly even if power is lost at the subscriber's location.

One problem with conventional approaches to cable modems is providing power to the modems. Cable modems can either be powered from a power source located at the subscriber's location or powered using network power. When local power is used, if the subscriber loses power, the cable modem ceases to function. This reduces the effectiveness of the cable company in competing

is understood that an implementation of network 100 can include any appropriate number of head end communication devices and any appropriate number of remote communication devices.

Remote communication device 104 includes circuitry that is used to communicate data to and from head end communication device 102. Remote communication device 104 includes receiver 110 and transmitter 124 that are coupled to communication link 106. Receiver 110 and transmitter 124 are also coupled to signal processing circuit 126. Signal processing circuit 126 is coupled to input/output devices (I/O devices) such as, for example, a computer, a telephone, a set top box, etc. Signal processing circuit 126 implements the communication protocols necessary for remote communication device 104 to operate in the environment of network 100. For example, signal processing circuit 126 may implement protocols for voice, data, and/or telephony signals in a wired or wireless network.

In one embodiment, remote communication device 104 is powered using power provided over network 100 so as to provide battery-backed power in the event of a power outage at the location of remote communication device 104. In an alternative embodiment, remote communication device 104 is powered from a battery or other power supply.

Remote communication device 104 includes control circuit 108 to reduce the power consumption at remote communication device 104. Advantageously, control circuit 108 reduces the power consumption of remote communication device 104 by selectively powering down receiver 110, or parts of the receiver circuitry, for a selected period of time. Control circuit 108 powers up receiver 110, or the necessary parts of the receiver circuitry, within an amount of time after power-down sufficient so as to assure that all data is properly received at remote communication device 104.

The duration of the power down should be selected so as not to interfere with the normal operation of an application. In the case of a telephone call, for example, the duration can be set at a time interval long enough that a first attempt to ring a telephone could be missed but short enough such that a second ring would always be successful. In the case of data, the time delay is set to a

sufficiently slight delay since only a slight delay can be tolerated on the first data packet of a data transfer such as web browsing.

Control circuit 108 includes processor 128. Processor 128 is coupled to counter 130. Processor 128 is also coupled to receive signals, including a "Last Packet Sent" message, from signal processing circuit 126. Processor 128 generates signals to selectively power down receiver 110 based on the signals from signal processing circuit 126 and counter 130 using, for example, the method shown and described with respect to Figure 3 below. Alternatively, processor 128 and counter 130 can power down receiver 110 for a time that does not interfere with the ability of receiver 110 to detect attempted retransmissions by head end communication device 102 once receiver 110 is powered up again.

Head end communication device 102 includes circuitry that is used to communicate data to and from remote communication device 104. Namely, head end communication device 102 includes signal processing circuit 112. Signal processing circuit 112 processes signals from the head end for transmission by transmitter 116 to remote communication device 104. Signal processing circuit 112 further processes signals from remote communication device 104 that are received at receiver 114.

In one embodiment, head end communication device 102 also includes control circuit 118 to provide a synchronous implementation. Control circuit 118 controls the transmission of signals by transmitter 116 over communication link 106 to receiver 110. Control circuit 118 includes processor 120 and counter 122. Processor 120 is programmed to determine when receiver 110 is powered-up to receive data from transmitter 116 using, for example, the process described below with respect to Figure 2.

In another embodiment, processor 120 uses the TCP/IP or similar retransmission protocol to cause transmitter 116 to retransmit unacknowledged packets until such time that receiver 110 is powered up and acknowledges receipt of data transmitted by transmitter 116. This is an asynchronous implementation.

Figures 2 and 3 are flow charts that illustrate methods that are implemented at a head end communication device and a remote communication device, respectively, to selectively control the power to a receiver of the remote

communication device. These methods work together to reduce the power consumed by the remote communication device. The flow chart of Figure 2 illustrates an embodiment of a method for controlling transmission of data by a head end communication device over a communication system to the remote communication device. The flow chart of Figure 3 illustrates an embodiment of a method for controlling the power to a receiver at the remote communication. Each of the flow charts are described in turn below.

The method of Figure 2 is implemented at the head end communication device and begins at block 200. At block 202, the head end communication device resets its sleep counter. The value of the sleep counter indicates when the receiver at the remote communication device is in a sleep or power-down mode. The reset of this sleep counter is substantially synchronized with the resetting of a similar sleep counter at the remote communication device because the remote communication device resets its sleep counter based on a "Last Packet Sent" message from the head end communication device as described in more detail below. Advantageously, the head end communication device maintains this substantial synchronization of sleep counters without receiving any signals from the remote communication device.

The head end communication device waits for the sleep counter to expire before transmitting any data to the remote communication device. At block 204, the head end communication device decrements its sleep counter. At block 206, the head end communication device determines whether the sleep counter has expired. If not, the method returns to block 204 and decrements the sleep counter. If the sleep counter has expired, the method proceeds to block 208 and sets a DelayFlag to a "reset" value.

With the sleep counter expired, the head end communication device next attempts to transmit data to the remote communication device since the receiver at the remote communication device should be powered up. At block 210, the head end communication device determines whether there are any data packets to be sent to the remote communication device. If there are data packets, the data packets are sent at block 212. At block 213, the method sets DelayFlag to "Reset" since DelayFlag must remain at a Reset value as long as data is being

received. The method returns to block 210. If there are no data packets, the method proceeds to block 214.

At block 214, the head end communication device checks the state of the DelayFlag. If the DelayFlag is not "SET," the head end communication device delays for X units, sets the DelayFlag to "SET" and returns to block 210 to determine whether there are any more data packets for the remote communication device. The delay, typically known as "guard time," at this point accounts for timing variations between the sleep counters at the head end communication device and the remote communication device. A similar delay is implemented at the remote communication device.

If at block 214, the head end communication device determines that the DelayFlag is "SET," the method proceeds to block 218 since data packets, if any, have been sent and the head end communication device has waited the established delay period for additional data.

At block 218, the head end communication device sends a "Last Packet Sent" message to the remote communication device. This allows the sleep counters at the head end communication device and the remote communication device to be substantially synchronized. The method returns to block 202 and resets the sleep counter.

The method of Figure 2 has been described in terms of a head end communication device that transmits packets to a single remote communication device. It is understood that this method can be used with a number of counters systematically adjusted in time at the head end communication device to control any appropriate number of remote communication devices.

The method of Figure 3 is implemented at the remote communication device and begins at block 300. At block 302, the remote communication device resets its sleep counter. The value of the sleep counter indicates when the receiver at the remote communication device is in a sleep or power-down mode. The reset of this sleep counter is substantially synchronized with the resetting of a similar sleep counter at the head end communication device because the remote communication device resets its sleep counter based on a "Last Packet Sent" message from the head end communication device as described above.

The remote communication device waits for the sleep counter to expire before checking for any data from the head end communication device. At block 304, the remote communication device decrements its sleep counter. At block 306, the remote communication device determines whether the sleep counter for the remote communication device has expired. If not, the method returns to block 304 and decrements the counter. If the counter has expired, the method proceeds to block 308 and powers up the receiver at the remote communication device to check for incoming data. The remote communication device also sets a DelayFlag to a "reset" value.

With the sleep counter expired, the remote communication device next checks for data from the head end communication device. At block 310, the remote communication device determines whether any data packets have been received from the head end communication device. If there are data packets, the packets are analyzed in turn at block 312 to determine whether a "Last Packet Sent" message has been received. When the "Last Packet Sent" message is received, the remote communication device powers down the receiver at block 318.

If at block 310, the remote communication device determines that no packets are available, the method proceeds to block 314. At block 314, the remote communication device checks the state of the DelayFlag. If the delay flag is not "SET," the remote communication device delays for X units, sets the DelayFlag to "SET" and returns to block 310 to determine whether there are any data packets from the head end communication device.

If at block 314, the remote communication device determines that the DelayFlag is "SET," the method proceeds to block 318 and powers down the receiver. The method returns to block 302 and rests the sleep counter.

Conclusion

Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that any arrangement which is calculated to achieve the same purpose may be substituted for the specific embodiment shown. This application is intended to cover any adaptations or variations of the present invention. For example, the techniques for reducing power consumption can also be used in other types of

communications networks, such as, for example, wireless networks (PCS and cellular). Further, other techniques can be used to select the time period of the sleep mode for the receiver at the remote communication device.

What is claimed is:

1. A method for controlling power consumption in a communication device, the method comprising:

powering down at least a portion of a receiver of the communication device for a selected period of time; and

when the selected period of time expires, powering up the at least a portion of a receiver to check for incoming data.

2. The method of claim 1, wherein powering down the at least a portion of a receiver for a selected period of time comprises powering down the receiver for a period of time sufficient to allow detection of an attempted retransmission of a packet.

3. The method of claim 1, wherein powering down the at least a portion of a receiver for a selected period of time comprises setting and decrementing a counter.

4. The method of claim 3, and further comprising synchronizing the counter with a counter disposed at a source of the incoming data.

5. The method of claim 1, wherein powering up the at least a portion of a receiver to check for incoming data comprises:

powering up the receiver;

checking for incoming data;

when no data is detected, checking for incoming data after another selected period of time;

when incoming data is detected, processing the data; and

when no incoming data is detected or a last data message is received, powering down the receiver for a selected period of time.

6. A communication device, comprising:

a transmitter that transmits data;

a receiver that receives data over a communications link;

a signal processing circuit, coupled to the transmitter and receiver, to prepare data for transmission and to process data received by the receiver; and

a control circuit, responsive to the signal processor, that selectively powers at least a portion of the receiver down for a period of time and that powers up the at least a portion of a receiver to check for incoming data when the selected period of time expires.

7. The communication device of claim 6, wherein the control circuit includes a counter that is synchronized with a counter at the source of the incoming data.

8. The communication device of claim 6, wherein the control circuit powers up the receiver to check for incoming data for at least a selected period of time.

9. The communication device of claim 6, wherein the control circuit selectively powers down the at least a portion of a receiver when a selected period of time after power-up has expired or when a signal indicates that a current data transmission is complete.

10. The communication device of claim 6, wherein the signal processing circuit comprises a signal processing circuit for a cable modem.

11. The communication device of claim 6, wherein the control circuit powers down the at least a portion of a receiver for a period of time sufficient to allow detection of an attempted retransmission of a packet.

12. A communication network, comprising:

a head end communication device;

at least one remote communication device that is communicatively coupled to the head end communication device; and

wherein each of the at least one remote communication device includes a control circuit that powers down a receiver of the at least one remote communication device for a selected period of time and that powers up the

receiver of the at least one remote communication device to check for incoming data from the head end communication device when the selected period of time expires.

13. The communication network of claim 11, wherein each of the at least one remote communication device is powered over the connection between the head end communication device and the at least one remote communication device.

14. The communication network of claim 11, wherein each of the at least one remote communication device comprises a cable modem.

15. The communication network of claim 11, wherein each of the remote communication device is communicatively coupled to the head end communication device over a communication network.

16. The communication network of claim 11, wherein the head end communication device transmits data with a protocol that allows for retransmission of data that is not acknowledged by the at least one remote communication device.

17. A power control circuit for a communication device, the power control circuit comprising:

a counter that establishes a selected time period for powering down a receiver of the communication device; and

a processor, coupled to the counter, that is programmed to control the reset of the counter, to power down the receiver, and to power up the receiver to check for incoming data when the counter indicates that the selected time period has expired.

18. The power control circuit of claim 17, wherein the counter establishes a time period that is sufficient to allow detection of a data packet that is retransmitted by another communication device when no acknowledgment signal is received by the other communication device.

19. The power control circuit of claim 17, wherein the processor is programmed to power up the receiver for a selected time period to check for incoming data.

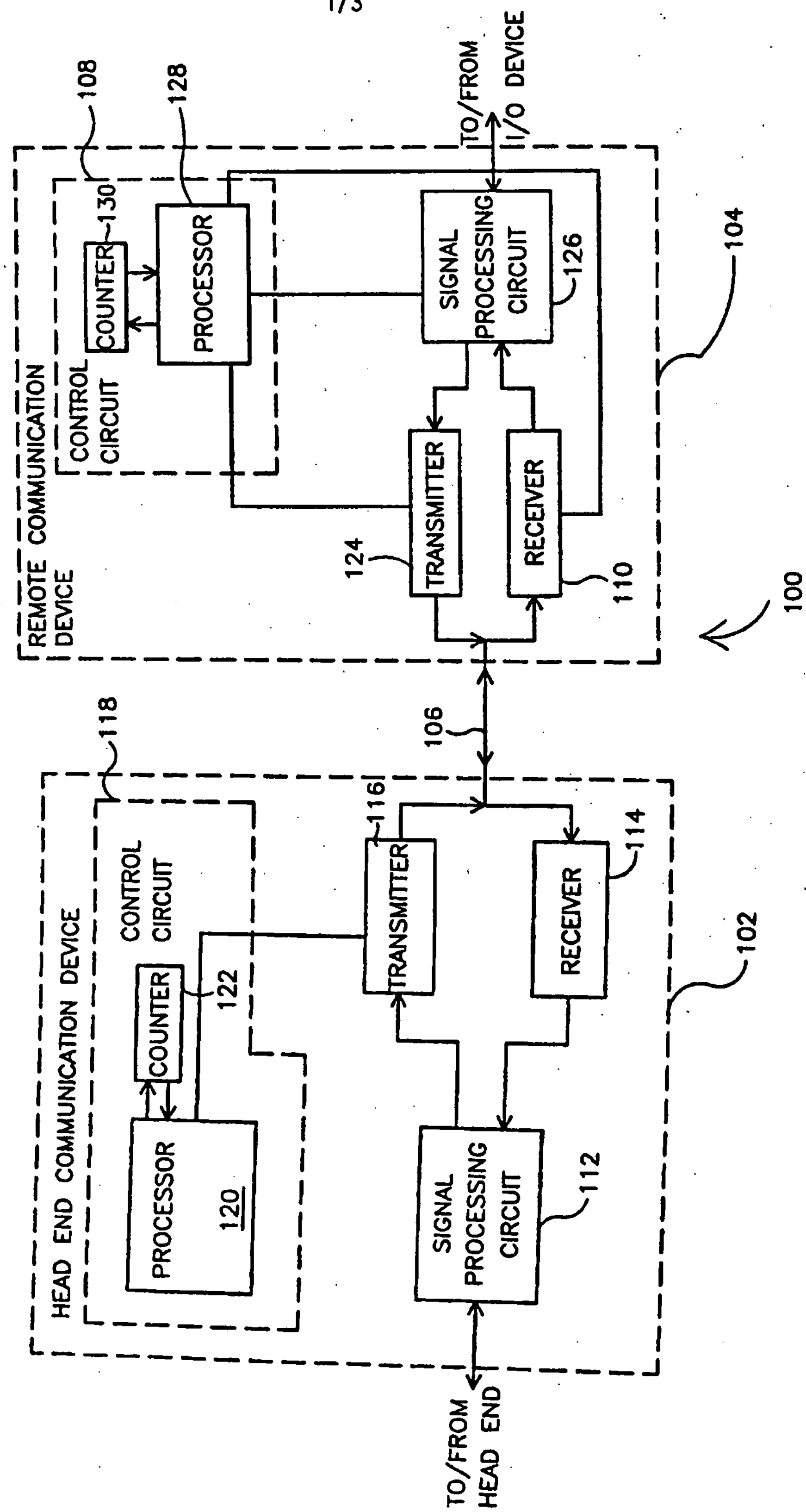

TO/FROM
I/O DEVICE
108
128
130
COUNTER
PROCESSOR
CONTROL
CIRCUIT
SIGNAL
PROCESSING
CIRCUIT
126
104
REMOTE COMMUNICATION
DEVICE
TRANSMITTER
RECEIVER
124
110
100
106
118
HEAD END COMMUNICATION DEVICE
CONTROL
CIRCUIT
COUNTER
122
PROCESSOR
120
116
TRANSMITTER
RECEIVER
114
102
SIGNAL
PROCESSING
CIRCUIT
112
TO/FROM
HEAD END

FIGURE 1

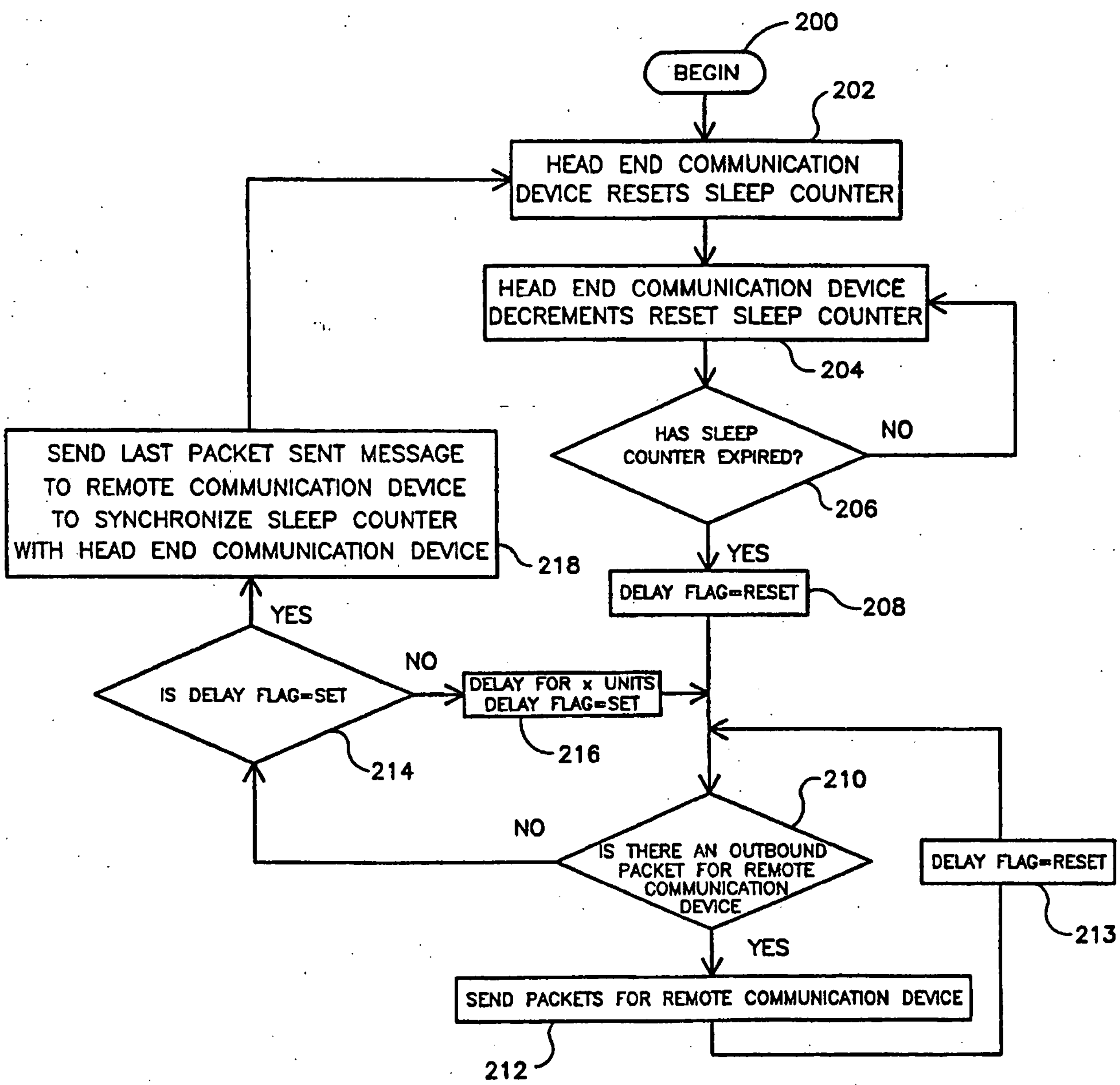
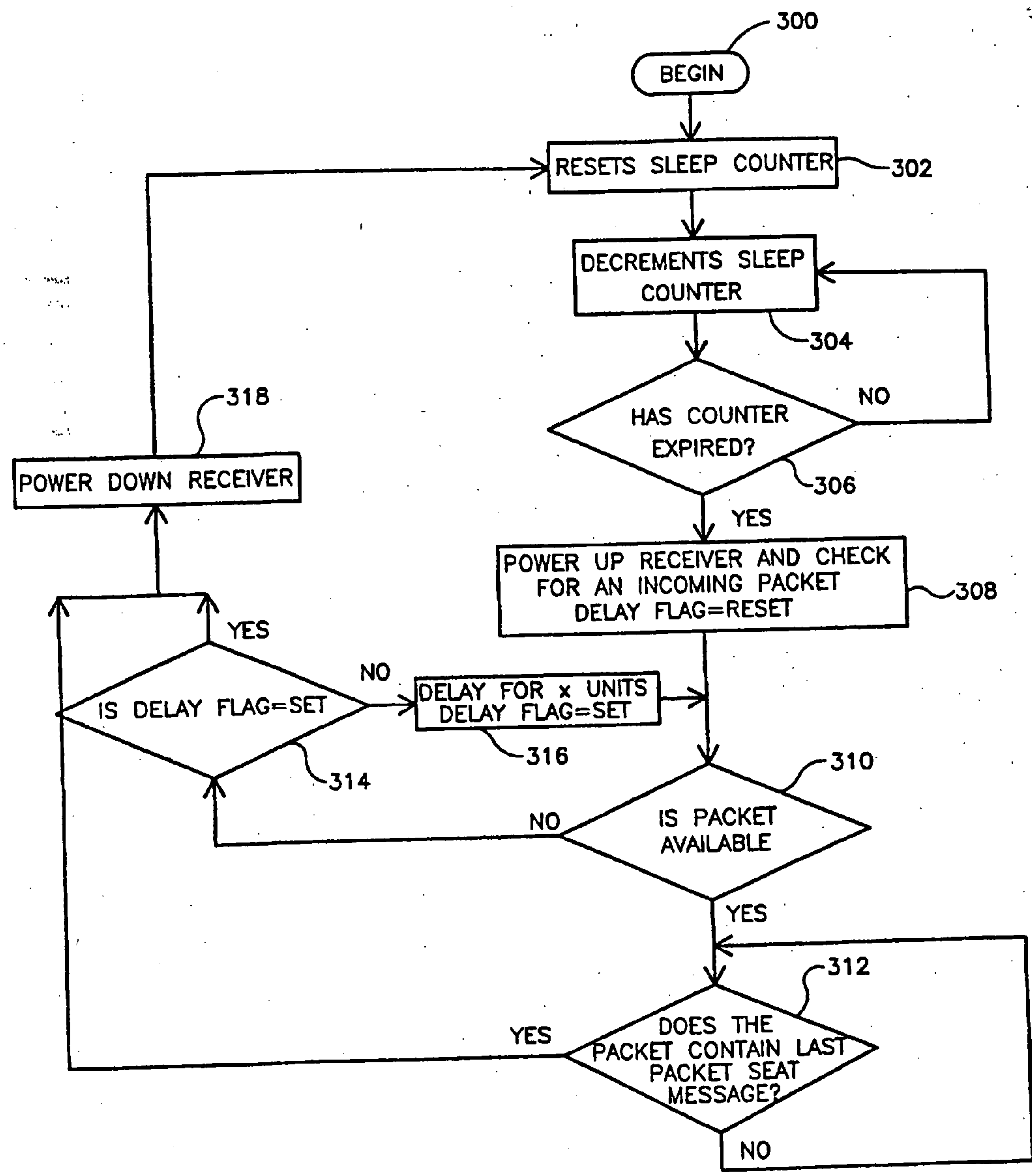

200
BEGIN
202
HEAD END COMMUNICATION DEVICE RESETS SLEEP COUNTER
HEAD END COMMUNICATION DEVICE DECREMENTS RESET SLEEP COUNTER
204
HAS SLEEP COUNTER EXPIRED?
NO
206
YES
DELAY FLAG=RESET
208
SEND LAST PACKET SENT MESSAGE TO REMOTE COMMUNICATION DEVICE TO SYNCHRONIZE SLEEP COUNTER WITH HEAD END COMMUNICATION DEVICE
218
YES
IS DELAY FLAG=SET
NO
DELAY FOR x UNITS DELAY FLAG=SET
216
214
210
NO
IS THERE AN OUTBOUND PACKET FOR REMOTE COMMUNICATION DEVICE
DELAY FLAG=RESET
213
YES
SEND PACKETS FOR REMOTE COMMUNICATION DEVICE
212

FIGURE 2



300
BEGIN
RESETS SLEEP COUNTER
302
DECREMENTS SLEEP COUNTER
304
HAS COUNTER EXPIRED?
NO
306
YES
POWER UP RECEIVER AND CHECK FOR AN INCOMING PACKET DELAY FLAG=RESET
308
318
POWER DOWN RECEIVER
YES
IS DELAY FLAG=SET
NO
DELAY FOR x UNITS DELAY FLAG=SET
316
314
310
IS PACKET AVAILABLE
NO
YES
312
DOES THE PACKET CONTAIN LAST PACKET SEAT MESSAGE?
YES
NO

FIGURE 3